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SCIENCE 8

MODULE 4:
The Earth's Crust

STUDENT SUPPORT GUIDE

Distance Learning

Alberta EDUCATION

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Science 8

Module 4

STUDENT SUPPORT GUIDE

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Student Support Guide
Module 4
The Earth's Crust
Alberta Distance Learning Centre
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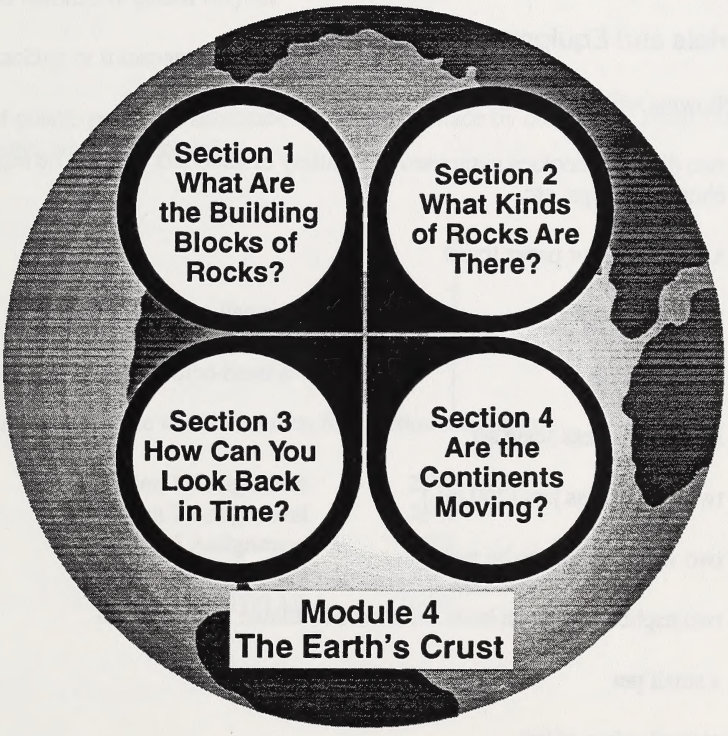
Module 4 – The Earth's Crust: Overview

The major emphasis of this module is the nature of science.

This module is a study of the make-up of the Earth's crust. Individual rocks, formations in which rocks are found, and the fossil record are examined. Also, a model of the Earth is presented to explain the ongoing process of change that leads to new rocks, new formations, volcanoes, earthquakes, and crustal movements.



Media

Video cassettes may be available from your local school jurisdiction or the Alberta Distance Learning Centre.

The following videos, though not included in the pathways, may be found useful:

- *The Earth Explored: Form and Function of Fossils*
- *The Earth Explored: Minerals and Rocks*
- *The Earth Explored: Inside Volcanoes*
- *The Earth Explored: Sandstone Secrets*
- *The Earth Explored: Plate Techtonics*

Materials and Equipment

The following will be needed:

- two different cookies composed of a variety of materials that can be separated such as nuts, chocolate chips, etc.
- a paper plate or paper towel
- mineral samples
- a streak plate
- Mohs' hardness scale set

or

- a small amount of table salt
- a hand-held magnifying glass

- two small glass jars (250 mL)
- two wax crayons (to be melted)
- two naphthaline moth balls, which are available at drug stores
- a small pot
- several cubes of ice
- a stove or hot plate
- petroleum jelly or cooking oil
- oven mitts or a cloth
- a butter knife
- 250 mL of fine sand

- 125 mL of cement
- a stir stick or spoon
- two plastic or aluminum plates or dishes
- one sugar cube
- various hard objects such as shells, coins, etc.
- a pair of scissors
- coloured markers or pencil crayons
- tape (masking or transparent)
- 500 g of plastic putty or a substitute which can be made by combining 1 cup flour, 1/2 cup salt, 1 cup water, and food colouring

Evaluation

The evaluation of this module will be based on four section assignments.

Section 1 Assignment	**25%**
Section 2 Assignment	**25%**
Section 3 Assignment	**25%**
Section 4 Assignment	**25%**
TOTAL	**100%**

Section 1: What Are the Building Blocks of Rocks?

Section 1: Activity 1

A plate or paper towel and two different cookies are needed for this activity. The purpose of this activity is for the student to understand that cookies are made up of component ingredients (for a later analogy with minerals and rocks). For this reason, it is important that the student works with cookies that can be physically broken down into their component parts, such as chocolate chips, nuts, etc. Fine-grained cookies that do not have such ingredients are not appropriate. If cookies with nuts, chips, etc., cannot be purchased or made, then an alternative such as a chocolate bar with large nuts, etc., could be used.

Caution: Check with students for food allergies before allowing them to handle and consume food products.

1. Fill in the chart.

	Ingredient 1	Ingredient 2	Ingredient 3	Total
Example	Chocolate Chips 30%	Nuts 20%	Fine-grained Batter 50%	100%
Cookie 1	*Answers will vary. The percentages for the ingredients of each cookie must add up to 100 percent.*			
Cookie 2				

2. List the components of one of your cookies.

   Answers may include nuts, chips, fine-grained cookie batter, oatmeal, fruit, etc.

3. In order to make the same kind of cookie again, what ingredients would you need?

   The ingredients would have to be exactly the same as the ingredients listed in question 1, or it would be a different kind of cookie.

4. If you wanted to make a different kind of cookie, how would you change the ingredients?

   You could, for example, not put any nuts in the cookie, but put more chocolate chips. Changing the amount and kind of ingredient could make it a different kind of cookie.

5. If you only have chocolate chips and no other ingredients, can you still make a cookie? Explain your answer.

   No, in order to have a cookie, you need several ingredients. If you only have chocolate chips, you really just have a pile of chocolate chips!

6. From your examination of the cookie, how do you think rocks could be similar to cookies?

   Answers will vary. One response may be as follows. Perhaps rocks are made up of different components, as cookies are.

Section 1: Activity 2

1. Describe one of the rocks and tell whether the rock appears to have more than one ingredient?

   The granite appears to be made up of tiny pieces of material. These particles vary in colour from black to grey to white. If students were able to locate their own samples, their samples will vary greatly in appearance. Only some rocks will show their constituent components.

2. Write a paragraph explaining in what way cookies are similar to rocks. In your paragraph you must use the following terms: minerals, rock, chocolate chips, nuts, cookies, and combine.

   Cookies are similar to rocks because ingredients such as batter, chocolate chips, and nuts combine to form a cookie, in the same way that minerals combine to form a rock.

3. Define the following terms.

   a. lustre: *the appearance of the surface of the mineral, for example, greasy, waxy, glassy, metallic*

   b. streak: *the colour of the powder of a mineral as observed when the mineral is scratched across a streak plate*

   c. hardness: *the hardness a mineral is on Mohs' hardness scale of 1 to 10*

4. What is an example of a mineral with a metallic lustre?

   Gold and silver have a metallic lustre.

5. If a mineral has a red streak, does this mean that the mineral is red in colour? Explain your answer.

   No, a mineral can be a certain colour (for example, grey) and have a different colour of streak (for example, red).

6. Using Mohs' hardness scale found on page 158 of your textbook, put the following materials in order from hardest to softest: a fingernail, knife blade, pencil lead, and emery paper.

   emery paper
   knife blade
   fingernail
   pencil lead

7. List the mineral that has the same hardness as the object listed.

   a. knife blade *apatite*

   b. emery paper *topaz*

   c. copper coin *calcite*

Section 1: Activity 3

The following are needed for Part A of this activity:

- mineral samples
- streak plate
- Mohs' hardness scale set

The following are needed for Part B of this activity:

- small amount of salt
- a few grains of sand
- a hand-held magnifying lens

1. Complete the table.

   Answers will vary depending on the mineral samples. A response for one sample is shown.

Sample Number	Colour	Luster	Streak	Hardness	Mineral Name
2	*black*	*almost metallic*	*dark grey*	*1.5*	*graphite*

2. Were some properties more useful for identifying minerals than others? Why?

   Answers will vary, but it should be noted that colour is not as useful as lustre or hardness because so many minerals have the same colour. Many minerals also share the same lustre, but a fewer number of minerals will share the same hardness, making it one of the more useful properties.

3. Would it be difficult to identify a mineral if you were only allowed to use one of the properties? Why or why not? Give an example.

   Yes, it would be difficult, because many minerals will share a single property. The greater the number of properties that you use, the more you will narrow down the range of potential minerals that your sample could be. For example, there are many grey minerals, but far fewer grey minerals with a hardness of 5-6, and only one grey mineral with a hardness of 5-6 and a red streak.

4. Draw the shape of one of the halite crystals.

   cube

5. What is the name for the shape of the halite crystals?

   The halite crystals are cubes.

6. Describe the colour and lustre of the mineral halite.

   The colour is clear to white and the lustre is glassy.

7. Would taste be a good test to help you identify salt? Why or why not?

   In this case taste would be a good diagnostic property, because salt has a unique taste. However, you would have to be careful about what you taste, because some things may be unsafe to taste.

8. Draw one of the sand grains.

   rounded

9. How is the shape of the sand grain different from that of the halite crystal?

   The sand grains are rounded, and the halite crystals are in cubes.

10. Do the sand grains show a crystal shape? If they do not, why do you think this might be so?

    The sand grains have been subjected to wind and water, which has caused the grains to become rounded.

11. Compare the hardness of the sand grains with that of the halite crystals. How are they different? (To do this, try to break the grains with a table knife or a pin.)

    Most of the sand grains are very hard and cannot be broken. The halite crystals are soft and can be broken.

Section 1: Activity 4

1. Do some research on the following minerals (use either an encyclopedia, a dictionary, or the library). Explain what element the mineral is mined for and how humans use the element.

   a. chalcopyrite:

      Chalcopyrite (Cu Fe S_2) is mined for the element copper, which is used in making alloys (blend of metals), electrical wires, as well as a constituent of some fungicides.

b. galena:

Galena (PbS) is mined for the element lead, which is used in pipes and fittings, as a pigment in paint (which can cause lead poisoning), and as a shield against radioactivity (the bib that you wear when the dentist takes xrays is lined in lead).

c. sphalerite:

Sphalerite (ZnS) is mined for zinc, which is used as a coating for iron to prevent rust, in the making of brass, and in electric batteries.

Section 1: Follow-up Activities

Extra Help

Section 1 focused on how minerals combine to form rocks and how you can use the properties of minerals to help you identify them. If you had any problems understanding the terms used, the following should help.

For each question read the definition and think of a word that fits. Write the word in the space.

1. the distinctive geometric shape that a mineral forms

   crystal

2. how hard a mineral is on Mohs' scale of 1 to 10

   hardness

3. a pure solid that occurs in nature

   mineral

4. the colour of the powder of a mineral as observed when scratched on a streak plate

   streak

5. one of the ten most common minerals

   rock-forming mineral

6. a combination of two or more minerals

   rock

7. a pure substance composed of only one type of particle

   element

8. the characteristics of a mineral

   properties

9. the colour of the mineral in natural light

   colour

10. the appearance of the surface of a mineral; for example, greasy, glassy, metallic, etc.

    lustre

Enrichment

Many minerals are valuable, not because they are useful, but because of their beauty. These minerals are called gemstones. Examples of such minerals include diamonds, amethysts, sapphires, and rubies. Research these gemstones in an encyclopedia, dictionary, or in the library. Report what they look like, where they are mined, and what elements they contain.

Diamond: Colour ranges from colourless to white to pale shades of yellow, orange, blue, and green. They can also be black. Diamonds are chiefly mined in Africa and Brazil, although industrial grade diamonds (for use in grinding tools and drill bits) are explored for in Canada. Diamonds are composed of carbon, the same as a pencil lead, but they have been subjected to expreme pressure.

Amethyst: Amethyst is purple in colour and is chiefly mined in Brazil and Uruguay, although amethyst of a lesser quality is also found in British Columbia. They are composed chiefly of the elements silicon and oxygen (SiO_2); therefore, it is merely quartz with impurities causing the purple colour.

Sapphire and Ruby: Both sapphire and ruby are the gemstone variety of the mineral corundum ($Al_2 O_3$), with the red variety being called ruby (the rarest and most valuable of all gemstones), and all other colours of gemstone quality being called sapphires. Thailand, Burma, and Sri Lanka are the chief localities of rubies and sapphires. The elements present are aluminum and oxygen.

Section 2: What Kinds of Rocks Are There?

Section 2: Activity 1

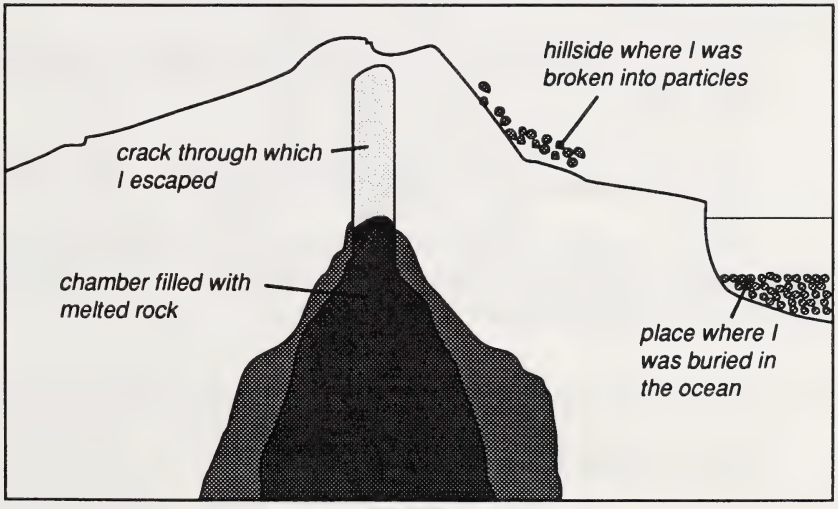
1. Describe three places in the story where rock is likely to form.

   Rock could form at any place in the cycle. Rock could form beneath the surface of the Earth in the magma chamber when the magma cools and hardens. Rock could form on the side of the volcano when the lava flows out onto the ground and hardens. Rock could form on the bottom of the ocean as the particles are buried.

2. In the space provided, sketch a diagram showing the journey of the rock in the story. In your diagram, label the underground chamber filled with melted rock, the crack through which you escaped, the hillside where you were broken into particles, and the place where you were buried in the ocean.

   In your diagram, label the underground chamber filled with melted rock, the crack through which you escaped, the hillside where you were broken into particles, and the place where you were buried in the ocean.

   Here is an example of a student diagram.


hillside where I was broken into particles
crack through which I escaped
chamber filled with melted rock
place where I was buried in the ocean

Section 2: Activity 2

1. What are the three main groups, or families, of rocks?

   Igneous, sedimentary, and metamorphic are the three main groups of rocks.

2. What does igneous mean?

   Igneous means *born of fire.*

3. What is the difference between magma and lava?

   Magma is molten rock beneath the surface of the Earth, and lava is molten rock that is at the surface of the Earth.

4. What is the difference between intrusive and extrusive igneous rocks?

   Intrusive rock is igneous rock that has cooled slowly beneath the surface of the Earth, and extrusive rock is igneous rock that has cooled quickly at, or near, the surface of the Earth.

5. Explain why sedimentary rock often has a layered appearance?

   Because it was deposited as particles, layer upon layer, sedimentary rock often has a layered appearance.

6. Explain the difference between a mudstone, a sandstone, and a conglomerate.

   All three are sedimentary rocks composed of particles, but a mudstone is composed of very small (mud-size) particles, the sandstone is composed of sand-size particles, and the conglomerate is composed of rounded pebbles and small stones.

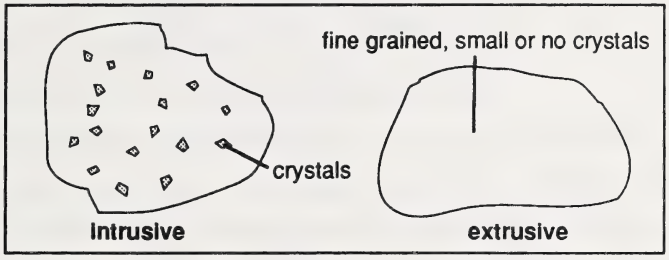
7. What two factors could cause an igneous or a sedimentary rock to become a metamorphic rock?

   Heat and pressure can cause this change.

8. You have been studying how igneous, sedimentary, and metamorphic rocks form and how they look.

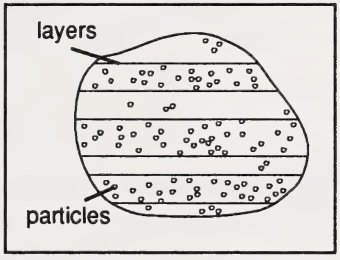
   Sketch examples of the three types of rock to show how they might look.

   a. Igneous



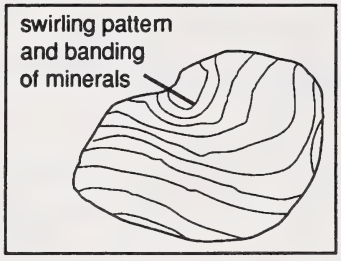
   The sketch should show crystals in intrusive igneous rock and either small or no crystals in the extrusive igneous rock.

   b. Sedimentary



   The sketch should show layering and particles.

c. Metamorphic



The sketch should show banding of minerals and/or a swirling or wavy pattern.

9. Explain how a metamorphic rock could become a sedimentary rock.

A metamorphic rock could become a sedimentary rock if it was weathered and eroded (broken into particles and then transported) and then compressed and cemented as a sedimentary rock.

Section 2: Activity 3

The following are needed for this activity:

- two moth balls
- a small pot
- an ice-water bath
- a stove or hot plate
- petroleum jelly or cooking oil
- oven mitts or cloth
- a butter knife

1. State the question that you are trying to answer by doing this experiment.

What is the relationship between rate of cooling and crystal size (in magma)?

2. State your hypothesis. In other words, state whether you think crystals will be larger in magma that cools slowly or in magma that cools quickly, and state why this would be the case.

Responses can vary. Two samples follow:

I think that the crystals will be larger in the magma that cools slowly because crystals need time to grow.

I think that the crystals will be larger in the magma that cools quickly because crystals form when cooled quickly.

3. For the two samples, describe any differences in texture or crystal growth.

   The sample that cooled quickly is very fine-grained with no or few crystals visible. In the sample that cooled slowly, radiating, needle-shaped crystals should be present.

4. Classify your two samples as either representing an intrusive rock or an extrusive rock.

   a. The one that cooled quickly represents the *extrusive* rock.

   b. The sample that cooled slowly represents the *intrusive* rock.

5. Based on your observations, what can you interpret or infer about the rate of cooling of magma and the size of crystals?

   If magma cools slowly, it will have crystals; but if it cools quickly, visible crystals will not have time to form.

6. Was your hypothesis supported by the data collected in the experiment? Explain.

   If the student predicted that the slowly cooling magma would have larger crystals, then the data supports the hypothesis. If the student predicted that the quickly cooling magma would have larger crystals, then the data does not support the hypothesis.

Section 2: Activity 4

1. Locate four samples of rock that have well-defined crystals, particles, banding, swirling, or other distinctive features. Then fill in the following chart.

   Answers will vary considerably, depending on samples available. Some samples will be very difficult to classify, so students should look for samples that have well-defined crystals, particles, or metamorphic features. Crystals can be differentiated from particles by the fact that crystals should have some type of geometric form where particles will be rounded or show random angles. Metamorphic rocks will show banding of minerals, intense veining, or a swirling pattern. It is more important that the student is carefully observing the rock, making notes, and inferences, than it is that he or she get the "right" answer.

2. Were there any samples that you found difficult to classify? If so, why?

   Answers will vary. It is here that the student should express the difficulties of classifying some rocks. The student should be aware that this is common and even geologists have difficulty classifying some rocks.

3. Which do you think is more attractive for items such as building stones and counter tops, natural rock or fake rock? Support your answer.

   Since this is an opinion question, answers will vary. However, it is expected that the student support his or her opinion by giving such reasons as these: natural stone is closer to the environment and gives the building a warmer feeling, or fake stone is better because it is more creative and you can have more control over exactly what you want.

4. Of the samples that you have described, which one did you like the best and why?

   Answers will vary considerably. Students are expected to give reasons for their choice.

Section 2: Follow-up Activities

Extra Help

1. Deep below the surface of the Earth there are huge spaces that are filled with red-hot, melted rock. This melted rock is called *magma.*

2. If this melted rock stays below the surface of the Earth, and cools very slowly to become solid rock, it will be called an *intrusive* igneous rock.

3. Because crystals take a long time to form and the melted rock took a long time to cool, the crystals in the rock will be *large.*

4. Sometimes the melted rock below the surface of the Earth does not stay there. At times it finds its way to the surface of the Earth and spills out onto the ground. This melted rock that is at the surface of the Earth is called *lava.*

5. If melted rock were to cool quickly, it would be called an *extrusive igneous* rock.

6. Because crystals take a long time to form, and this rock cooled quickly, the crystals in this rock will be *small.*

7. If a rock is buried deep in the Earth and is put under extreme pressure and temperatures that are close to 1000°C, it will change into a new kind of rock that is called *metamorphic* rock.

8. Sometimes a rock will be broken up into tiny pieces and then carried away by wind or water. If these pieces of rock are later cemented together to form a new rock, it will be called a *sedimentary* rock.

9. If you found a rock and it had crystals in it, you would suspect that it is a *igneous* rock. If it was composed of particles, you would suspect that it is a *sedimentary* rock. If it had swirls in it and it looked like it had been squeezed, then you might think that it is a *metamorphic* rock.

Enrichment

Write your own story about how one rock was changed at least three different times into a new type of rock. If you choose, you can pretend to be the rock and describe your incredible journey the way you imagine it.

Students should demonstrate an understanding of the rock cycle by describing how their rock was changed by any combination of re-melting, erosion and deposition, pressure, and temperature, etc. A sample answer is given.

I had just been blasted out of a volcano and was lying on the side of the volcano. Years went by, and I found myself getting buried deeper and deeper, as layers of rock built up over me. As the pressure and temperature increased, I found myself changing into a metamorphic rock. Millions of years passed by, and the layers of rock over me were eroded away. Finally I was exposed to the surface, broken up, and washed to the sea, where I was deposited and pressed into a sedimentary rock.

Section 3: How Can You Look Back in Time?

Section 3: Activity 1

1. According to this story, if you wanted to find something that you left on the floor many years ago, where would you expect to find it?

   Because it was left a long time ago, you would have to dig down a long way to find it closer to the floor.

2. If you wanted to find something that you dropped only a week ago, where would you expect to find this item?

   This item would be close to the top because it has not been there long enough to be buried very deep.

3. Examine the drawing of the mountain, and then put the following events in order from the first event to occur to the last event to occur.

   - layer X was deposited
   - the tree on top of the mountain grew
   - layer Y was deposited
   - layer Z was deposited

   a. first event *layer Y was deposited*

   b. second event *layer X was deposited*

   c. third event *layer Z was deposited*

   d. fourth event *the tree on top of the mountain grew*

4. How did you figure out the order of these events?

   The layer that is lowest in the sequence had to be deposited first in order for the other layers to be deposited on top of them. This is what the principle of superposition says. Of course, the layers had to be there for the trees to be able to grow on top.

5. Take a walk, and list five different places where you can see that the principle of superposition applies. To start you off, an example would be the books on your desk.

   Examples may include bricks in a wall, a stack of newspapers, cookies in a cookie jar, snow in a snow drift, boards stacked in a yard, etc.

Section 3: Activity 2

The following are needed for this activity:

- 250 mL of fine sand
- 125 mL of cement
- a stir stick or spoon
- two plastic or aluminum plates or dishes
- one sugar cube
- various hard objects such as shells, coins, etc.

1. List several items which you think would turn into a fossil and survive millions of years. Why did you select these items?

   Some possible student responses:

   bones – they do not rot
   tools, such as knives, etc. – they are made of hard materials that do not rot

   This is an exploration activity; hence the correct answer is not important. The student is expected to ponder the possibilities of what makes a fossil and why it will make a fossil.

2. According to the definition of fossil that is given, which of the following would be considered a fossil? Explain why they are or are not fossils.

   a. a dinosaur bone

      It is a fossil because it is the remains of a prehistoric organism that have been preserved by natural means.

   b. a cow bone (recent)

      It is not a fossil because a cow is not a prehistoric animal.

   c. a two-hundred-year-old arrowhead

      It is not a fossil because it is not a remains or trace of a prehistoric organism. The remains of human activities are called artifacts.

   d. the footprint of a bird that lived 20 000 years ago

      It is a fossil because it is the trace of a prehistoric organism.

3. Which of the following organisms would most likely be fossilized? Explain your answer.

   a. a crab

      A crab is very likely to be fossilized because it has many hard parts and it lives in the water where it may become covered in sediment.

   b. a flower

      A flower is less likely to be fossilized because it is not likely to be covered in sediment and it has no hard parts.

c. a fish

A fish is quite likely to be fossilized because it lives in the water where it may become buried in sediment and it has a skeleton which is more likely to be preserved.

d. a bird

A bird has a small chance of being fossilized because it does have a hard skeleton; but it is less likely to be buried in sediment because it does not live in the water.

Comment: It should be emphasized to the student that fossilization of any organism is quite rare, but living in an environment where the organism may be quickly covered in sediment and having hard parts will increase the likelihood of being fossilized.

4. Using what you have learned, define the term fossil in your own words.

The student answer should state

- *that a fossil can be either the actual remains or the trace of an organism*
- *that it must be preserved by natural means*
- *that it must be a prehistoric organism*
  This is at times difficult to define, but for society's purposes, it must be thousands of years old.

5. In what type of rock are fossils most likely to be found?

Fossils are most likely in sedimentary rock.

6. In what order will you expect to find the fossils (from bottom to top)?

The fossils would be in the order C, B, A.

7. In the previous example, which fossil (A,B, or C) is the oldest? How do you know?

Fossil C is the oldest because it is in the bottom layer of rock. According to the principle of superposition, the rock on the bottom is older than the rock above it. This would apply to fossils too.

8. In Alberta it is possible to find samples of petrified wood. Explain how this wood became petrified.

   After the wood was buried by sediment, minerals were deposited in the pores (air spaces) in the wood. As the years went by, minerals replaced more and more of the wood, until it was completely petrified.

9. Refer to question 3 on page 178 of your textbook. What is the proper order for the illustrations.

   The proper order for the illustrations is c, b, a, d.

10. Using your knowledge of fossil formation, predict which items on the expedition will be fossilized and then discovered in a million years. Also indicate what conditions will be necessary for the fossilization process to take place.

    Answers will vary considerably; however, the students are expected to apply their understanding of fossil formation to whatever item they choose. Also, the proper definition of a fossil must be adhered to. Therefore, items such as tools are not considered fossils, but rather artifacts. Therefore, the items most likely to be fossilized would be the bones of the humans and the camels (which will be prehistoric organisms in a million years).

    Conditions for fossilization to take place would include rapid burial by sediment.

Section 3: Activity 3

1. List the organisms that you saw in the order in which you encountered them.

   microscopic one-celled organisms (detected), fish, insects, amphibians, huge plants, dinosaurs, mammals, human-like organisms, and humans

2. In what general ways would you say the organisms changed from the beginning of time to the present?

   The correct response is that the organisms got more complicated and more diverse (different types). However, students may also note that they got bigger. It should be noted that small, one-celled organisms still do exist, and that the dinosaurs were the biggest of all (which may, in part, have caused their extinction).

3. If you were to examine the layers of rocks in the Grand Canyon from the bottom to the top, what fossils would you find?

   At the bottom of the canyon in the oldest rocks there are no fossils. As you move up the canyon into younger rocks, trilobites appear, which are the oldest fossils. As you move further up into still younger rocks, the fossils become more similar to those living today.

4. What is the name for the divisions which the geological time scale is divided into?

   The divisions are called eras.

5. Fill in the blanks with the appropriate name of the era.

   a. The Earth was formed during the *Precambrian* era.

   b. The first human-like species appeared during the *Cenozoic* era.

   c. The first reptiles appeared during the *Paleozoic* era.

   d. The first flowering plants appeared during the *Mesozoic* era.

   e. The first birds appeared during the *Mesozoic* era.

6. Elements that decay and change into a new type of element are called *radioactive* elements.

7. Give an example of a element that changes into a new kind of element, and tell what new element it turns into.

   Uranium turns into lead.
   Rubidium turns into strontium.

8. When does the radioactive clock of a rock start?

   The radioactive clock starts when the mineral containing the radioactive element first crystallizes.

9. How would you compare how long humans have been on the Earth with how long the Earth has been in existence?

   Humans have been in existence only a small fraction of the time that the Earth has been in existence.

10. Imagine that you are a palaeontologist (a geologist who studies fossils) who has been hired by a museum. Your job is to design a display that will show what Alberta was like during the Mesozoic era. Indicate what you will include in your display. (You may wish to draw a diagram of your display.)

    The student's answer should include that the environment of Alberta during the Mesozoic era was tropical. During part of the Mesozoic era, much of Alberta was covered by shallow seas. Areas not covered by water were swampy and rich in vegetation. Dinosaurs were the dominant form of animal life. A sample display is shown.

Section 3: Follow-up Activities

Extra Help

Complete the following questions.

1. Suppose you were to pour some red gravel into a bucket, and then a layer of blue gravel, and finally a layer of purple gravel. Which layer would have been in the bucket for the longest amount of time?

   The layer of the red gravel would have been in the bucket for the longest amount of time.

2. Which layer in the previous example is the lowest layer?

   The red layer is the lowest layer.

3. Suppose that in this example you were to find fossil A in the red layer, fossil B in the blue layer, and fossil C in the purple layer. Which fossil would have been in the bucket longer?

   Fossil A would have been in the bucket the longest.

4. The principle that states that the layer on the bottom is older than the layer above it is called the *principle of superposition.*

5. If minerals replace the material that makes up a bone, the bone is said to have been *mineralized.*

6. If mud fills in the footprints of a dinosaur and becomes hardened into sedimentary rock, which preserves the original shape of the footprint, the type of fossil left is called a *mould.*

7. If sand fills in a seashell and later becomes a rock having the shape of the seashell, the type of fossil formed is said to be a *cast.*

8. In your life you use a calendar to keep track of events. Geologists use the *geological time scale.*

9. The large units which divide up the geological time scale are called *eras.*

10. Geologists can tell how old a rock is by looking for *radioactive* elements which break down into different elements at a certain rate.

Enrichment

Write a report on either the Paleozoic or the Cenozoic era. In your report tell what plants and animals existed and what the environment was like in Alberta during that era.

The following is a brief outline of part of what may be included in the student's report. However, it is recommended that the student's information be confirmed by checking the references used.

Paleozoic
- *complicated organisms become common, such as marine-dwelling organisms with eyes and shells (eg. trilobites)*
- *shallow seas covered parts of Alberta*
- *large plants become common*

Cenozoic
- *Alberta no longer covered with water*
- *mammals replace the dinaosaurs*
- *human-like species appear*

Section 4: Are the Continents Moving?

Section 4: Activity 1

The following are needed for this activity:

- a pair of scissors
- coloured markers or pencil crayons
- tape

1. In the space provided list three things that might be different in your life if all of the continents were made into one huge continent. Think of things such as relatives in other countries or the price of things that come from other countries.

   Student responses may include visiting family in other countries more often, items such as stereos, etc., would be less expensive, different types of food would be readily available, fashions may change, you may need to learn more languages, and people may become more tolerant of other customs.

2. Match the term describing the zone of the Earth with the appropriate part of a hard-boiled egg.

   a. the crust *the shell*

   b. the core *the yolk*

   c. the mantle *the egg white*

3. Look at the map. What do you notice about the shapes along the east coast of North and South America and the west coast of Europe and Africa? Can you make an inference about where the continents used to be?

   The student should notice that the two coast lines fit together like a jigsaw puzzle. Based on this observation, the student may infer that at one time the continents were joined together.

4. What evidence did Wegener give to support his theory of continental drift?

   The rocks found in northern Europe are similar to those found in the Appalachian Mountains on the opposite side of the Atlantic.

   The rocks found on the west coast of Africa are similar to those found on the east coast of South America, as well as the fossils are similar on both sides of the ocean.

5. What new evidence did scientists come up with to support the idea of drifting continents after Wegener died?

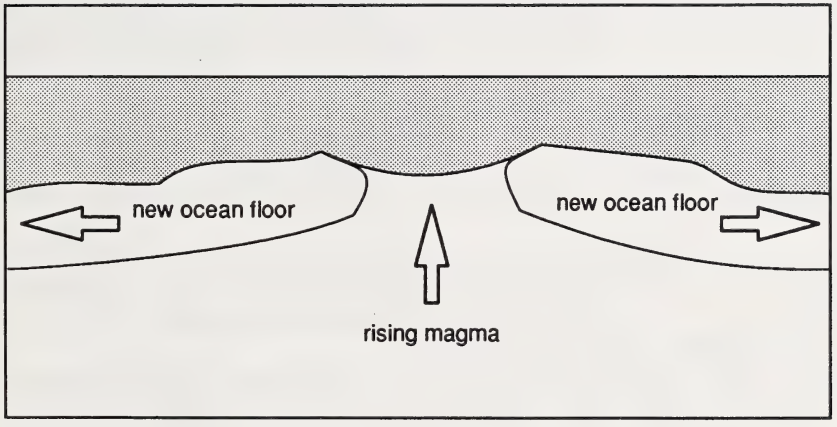
   The Mid-Atlantic Ridge was discovered, where new oceanic crust is being formed, pushing the plates apart.

   Ocean trenches were discovered where one plate slipped down beneath another, was pushed into the mantle, and was re-melted.

6. If new crust is being made at spreading centres and the Earth is not getting bigger, where does the old crust go?

   It is "consumed" at ocean trenches. Here it slips down beneath another plate, is forced down into the mantle, and is re-melted.

7. Do Activity 4-12, Sea-Floor Spreading, on page 208 of your textbook. This will help you visualize how new sea floor is being made. Answer the following questions.



Textbook question 1. (a): *the mid-ocean ridge*

Textbook question 1. (b): *the crust of the Earth being formed*

Textbook question 2. (a): *the rock that was formed first*
The rock farthest from the the ridge is oldest.

Textbook question 2. (b): *The youngest rock is the one closest to the centre of the ridge.*

Textbook question 3: *The oldest rock, or the rock that came up from the mid-ocean ridge first, would be closest to a trench.*

8. Trace the map of the world, found on page 204 of your textbook, onto a blank piece of paper. Cut out the continents. Using this as a model, explain the theory of continental drift to a friend, a relative, or your learning facilitator. In your explanation, you must

    - start with the continents grouped together
    - show how the continents spread apart
    - show where new sea floor is made
    - explain the evidence that supports this theory

    This activity is designed to allow the student to internalize the concepts that he or she has learned. This is facilitated by giving the student the opportunity to share his or her knowledge. The student is expected to follow the guidelines provided, indicating that new sea floor is made at the mid-ocean ridge (halfway between the two spreading continents) and discussing how similar rocks and fossils match up on the opposite coasts.

Section 4: Activity 2

1. Do you think an earthquake could occur where you live? Give reasons for your answer.

    This is an exploration activity, so getting the "correct" answer is not as important as the student taking the time to think about whether or not an earthquake could occur where they live. Because Alberta is not near a plate boundary, the chances of a major earthquake are minimal.

2. Describe any similarities that you can see between the pattern of earthquakes and the plate boundaries.

    The student should notice that the vast majority of earthquakes occur on or near plate boundaries.

3. Where do earthquakes usually take place?

    Earthquakes usually take place near major faults or plate boundaries.

4. List three examples of the damage that can occur during an earthquake.

    Student answers may include

    - *pavement cracking*
    - *gas and water lines breaking*
    - *buildings slipping into the ocean*
    - *waves are created in the ocean which wash buildings and people away*

5. Draw and describe an earthquake-proof building as you would build it.

Of course, student plans will vary widely. It is expected that the plans are realistic and will incorporate such things as extra reinforcement, flexible or suspended frames, solid foundations, and the avoidance of materials such as brick. An example of an earthquake-proof building is shown on pages 202 and 203 of Science Directions 8.

Section 4: Activity 3

1. What happens to a plate when it is thrust down beneath another plate and melted?

It becomes magma, and may find its way up through a weak spot in the crust of the Earth and come out of a volcanoe as lava.

2. Why do volcanoes and earthquakes often occur at plate boundaries?

Earthquakes occur at plate boundaries because the plates are moving, colliding, and grinding past each other, which casuses vibrations. Volcanoes occur at plate boundaries because if one plate slides underneath another plate, it will become melted, and the magma will find its way to the surface through a volcano.

3. Describe the three types of volcanoes.

Cinder cones are small, and they hurl small bits of volcanic material into the air producing the small cone shape.

Shield volcanoes are the largest in the world, and they are made almost entirely of lava flows. They have gentle slopes and resemble a shield lying on the ground.

Composite cones are composed of alternating layers of lava and volcanic material that was hurled through the air.

4. When did Mount St. Helens erupt?

Mount St. Helens erupted in May 1980.

5. What damage did the volcano cause?

When Mount St. Helens erupted, it totally flattened 400 square kilometres of forest.

It could also be pointed out to the student that many buildings were destroyed, millions of dollars of damage was caused, and some lives were lost.

6. Suppose a friend tried to explain why volcanoes and mountains occur. Your friend said that they were due to the Earth's centre cooling and shrinking, and the result was a wrinkling and cracking of the Earth's crust.

   Why is your friend's explanation wrong?

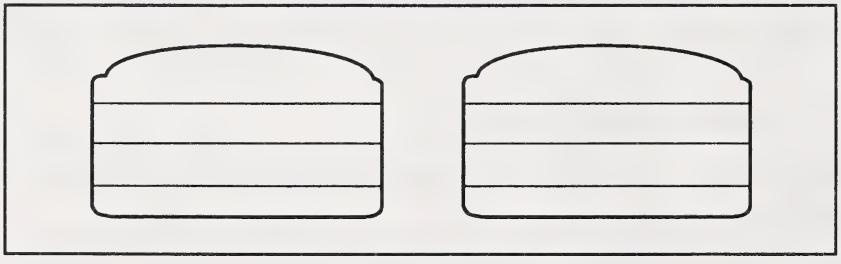
   If the friend's explanation were correct, volcanoes (and mountains) would be distributed very randomly over the globe. In fact, volcanoes (and mountains) do not occur everywhere; instead they occur in patterns. Students may notice that volcanoes largely follow the plate boundary and earthquake locations.

Section 4: Activity 4

For this activity, 500 g of plastic putty or a homemade substitution is needed.

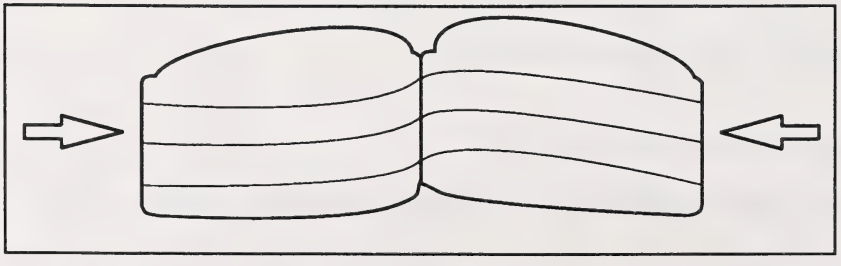
The required amount of the substition can be made by combining 1 cup flour, 1/2 cup salt, 1 cup water, and food colouring.

1. Draw a diagram of the two cakes, side by side. Make sure you show the layers.



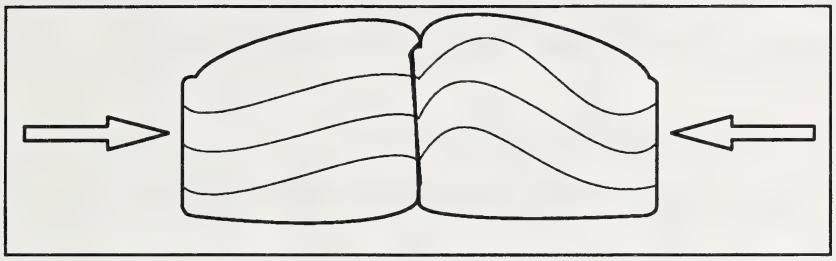
2. Draw a diagram of what would happen to the shapes of the layers when you start to push gently on each other's cake. Concentrate on what happens to the shapes of the layers.

   The student should show that the layers in the cakes are starting to fold from the pressure.
   Graphic



3. Draw a diagram of what the layers in the cakes will look like after you have put even more pressure on them.

   The students diagram should show that the layers in the cakes have become serverely folded and possibly even broken (faulted).



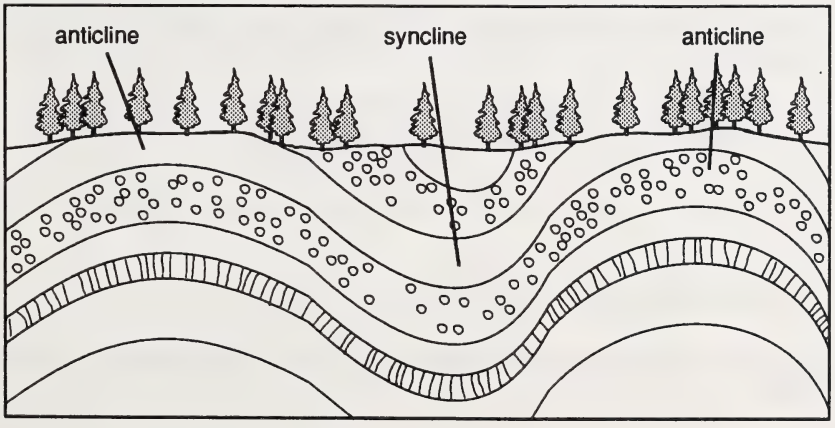
4. How are mountains made of sedimentary rocks similar to layer cakes?

   The student should indicate that both have been built up in layers.

5. When two plates collide, what will happen to the layers of sedimentary rock that are on the edges of the plates?

   The layers of sedimentary rock will become folded, faulted, and deformed as they are pushed up to form mountains.

6. Label the anticlines and synclines in the following diagram.



7. In order for rock to become folded, what two conditions must be present?

   Heat and pressure must be present.

8. What is a fault?

   A fault is a crack in the Earth's crust along which movement takes place.

9. What could cause rock to fault instead of fold?

   A section of rock may fault if it has already been folded and the pressure continues.

10. State at least one question that you will be trying to answer. If you need to, read the preceding paragraph again.

    The two questions that the student should be trying to solve in this experiment are

    - *What will happen to layers of rock (plastic putty) when a pushing force is exerted on them?*
    - *What will happen to layers of rock (plastic putty) when a pulling force is exerted on them?*

11. Propose a hypothesis stating what you think will happen to the layers of putty when you push on them and pull on them. Also, tell why you think it will happen.

    The students are free to make their own hypotheses, but they should give a reason for their predictions. A sample follows:

    When I push on the layers of plastic putty, the layers will fold because they are not rigid enough to withstand the force.

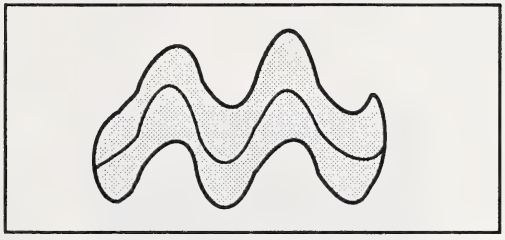
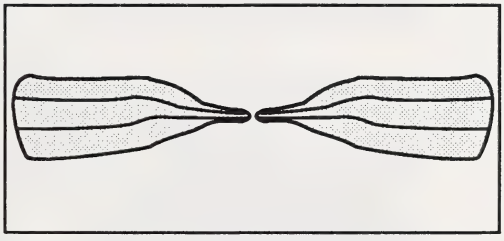
12. What happened as you pushed the layers from both sides?

    The student should observe that the layers thicken, fold, and if enough pressure is applied, fault.

13. What happened as you pulled the layers from both sides?

    The student should observe that the layers become thinner, and if enough tension is applied they will break.

14. Organize your data in chart form. Your chart must show the two forces that you applied to your putty and what you observed as the results of these forces.

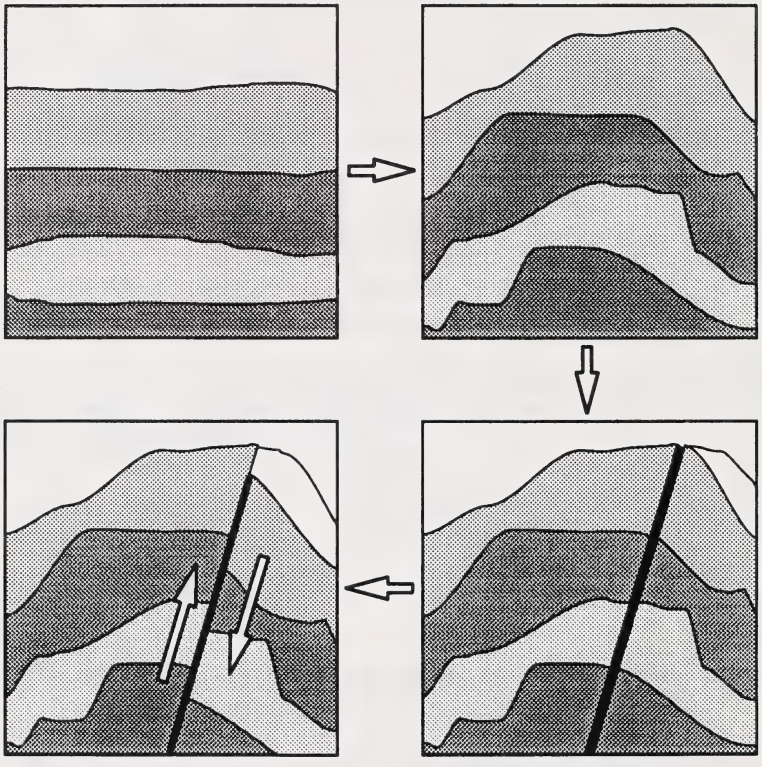
Force	Observations
Pushing	*The plastic putty folded into tight u-shaped folds.* 
Pulling	*The plastic putty got thinner and then broke.* 

15. From what you observed about your putty model, what can you infer will happen to rock layers when pushing or pulling forces are exerted on them?

It is expected that the student will be able to infer that when pushing forces are exerted on layers of rock, they will thicken, fold, and possibly fault. When pulling forces are exerted on layers of rock, they will become thinner and possibly break.

16. Using a sequence of diagrams, explain what happened to the layers of rock to make them look the way they do.

Using diagrams, the student should show that the layers of rock started out flat, became folded, and then faulted. Finally, movement occurred along the fault. An example of diagrams that may be used is shown.



Section 4: Follow-up Activities

Extra Help

1. The three zones of the Earth are the *crust*, *mantle*, and the *core*.

2. A segment, or part, of the crust is called a *plate*.

3. The theory which says that the crust of the Earth is divided into a series of plates which move and interact is called the theory of *plate tectonics*.

4. New crust is being formed at *mid-ocean ridges (or spreading centres)*.

5. Old crust is destroyed or consumed at *deep-sea trenches*.

6. Most earthquakes and volcanoes occur close to *plate boundaries*.

7. The three types of volcanoes are *cinder cones*, *shield volcanoes*, and *composite cones*.

8. The smallest type of volcano is the *cinder cone*.

9. The type of volcanoes that erupt mainly lava are called *shield* volcanoes.

10. Mountains are usually formed near *plate boundaries*.

11. Breaks or cracks in the Earth's crust along which movement takes place are called *faults*.

Enrichment

There are many famous volcanoes in the world. Choose either Paricutin or Mount Pelee. Do some research on it. Write a brief report stating when the volcano erupted, what damage was caused, and any interesting facts that you can find about the volcano.

The following will relate to the student's answers.

Paricutin began to grow in 1943 in a farmer's field. He tried to cover it up, but it continued to grow. In one year it was 430 m high. It eventually covered the town of San Juan.

Mount Pelee began to erupt on the island of Martinique in the Caribbean on April 23, 1902. It started slowly, but then on May 5, muddy ash rushed down the mountain and buried forty people alive. Then on May 8 the entire mountain exploded and a fiery cloud rushed down the mountain killing 30 000 people. Two people in the town survived.

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the Student Support Guide is not available
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